This Page Is Inserted by IFW Operations
and is not a part of the Official Record

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images may include (but are not limited to):

- BLACK BORDERS
- TEXT CUT OFF AT TOP, BOTTOM OR SIDES
- FADED TEXT
- ILLEGIBLE TEXT
- SKEWED/SLANTED IMAGES
- COLORED PHOTOS
- BLACK OR VERY BLACK AND WHITE DARK PHOTOS
- GRAY SCALE DOCUMENTS

IMAGES ARE BEST AVAILABLE COPY.

As rescanning documents *will not* correct images, please do not report the images to the Image Problem Mailbox.

THIS PAGE BLANK (USPTO)

(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 264 734 A2

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
11.12.2002 Bulletin 2002/50

(51) Int Cl.[7]: **B60R 1/00**

(21) Application number: **02253992.8**

(22) Date of filing: **07.06.2002**

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE TR
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: **08.06.2001 JP 2001174620**

(71) Applicant: **FUJI JUKOGYO KABUSHIKI KAISHA**
Tokyo (JP)

(72) Inventor: **Ikeda, Atsushi,**
c/o Fuji Jukogyo Kabushiki Kaisha
Tokyo (JP)

(74) Representative: **W.P. Thompson & Co.**
Coopers Building,
Church Street
Liverpool L1 3AB (GB)

(54) Vehicle surroundings monitoring apparatus

(57) A vehicle surroundings monitoring apparatus 2 has cameras having optical axes respectively, provided with imaging lens systems 5,6 each having a fish-eye lens 5a, 6a, image processing units 7, 8 and a calculating unit 9. The image processing units 7, 8 detect moving objects, such as vehicles traveling alongside a host vehicle provided with the vehicle surroundings monitoring apparatus, and oncoming vehicles, on the basis of optical flow between two images taken by the cameras at different times, respectively, and set a representative point representing the detected moving object on the surface of a road. The calculating unit calculates the position of the moving object relative to the host vehicle on the basis of displacement angles α and β of the representative point A with respect to the optical axis on an assumption that the representative point A is on a plane including a surface with which the host vehicle is in contact.

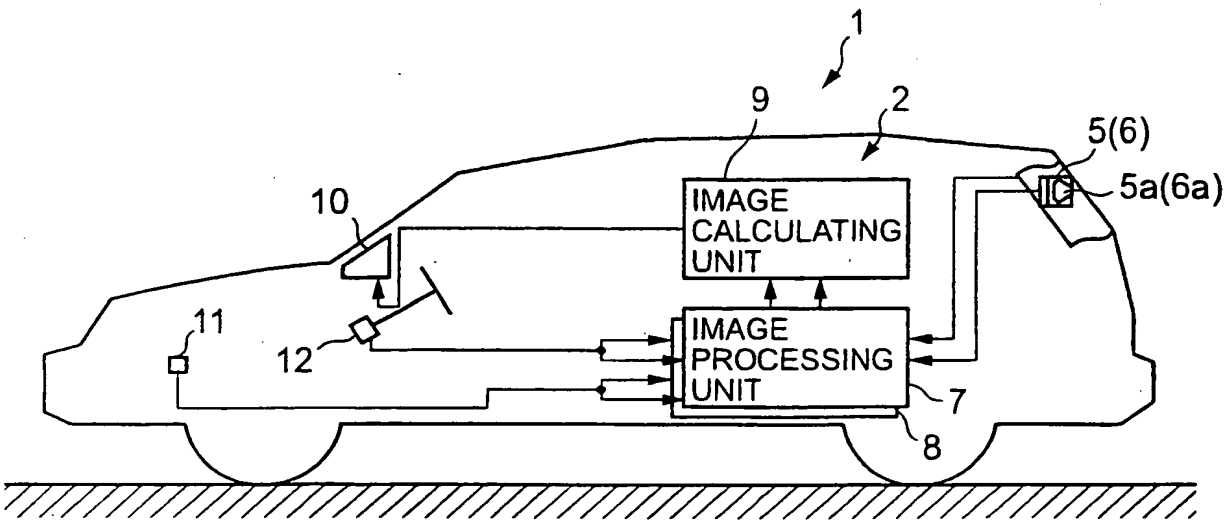

FIG.1

EP 1 264 734 A2

Description

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present invention relates to a vehicle surroundings monitoring apparatus for a vehicle, capable of detecting moving objects, such as vehicles traveling around a vehicle provided with the vehicle surroundings monitoring apparatus (hereinafter, referred to as "host vehicle"), on the basis of images provided by a fish-eye lens.

Description of the Related Art

[0002] Various types of vehicle surroundings monitoring apparatuses have been proposed and applied to practical uses in recent years for the improvement of safety of vehicles. Those vehicle surroundings monitoring apparatuses are capable of three-dimensionally recognizing roads and traffic conditions in a practically satisfactory accuracy and in a practically permissible time by obtaining images of scenery extending ahead of the host vehicle or objects lying in front of the host vehicle by a camera and processing the images.

[0003] A technique proposed in, for example, JP-A No. 283461/1998 by the applicant of the present patent application subjects images taken by a pair of cameras (stereo camera) to a stereoscopic process to detect the preceding vehicle and obstacles.

[0004] It is desirable, for the further improvement of the safety of the host vehicle, to give information about other vehicles and the like traveling beside the host vehicle to the driver in addition to that about a space in front of the host vehicle. Preferably, an image of scenery extending around the side of the host vehicle is obtained by a camera provided with a fish-eye lens to acquire information about a wide range of the side scenery. For example, a technique disclosed in JP-A No. 202180/1997 obtains an image of the side scenery by a fish-eye lens camera, converts the image into a regular image signal by a coordinate transformation circuit, and displays an optional region of a rectified image on the screen of a monitor. However, since this technique merely displays the image of a predetermined part of the vehicle's surroundings on the screen of the monitor, it is difficult to give the driver distance information representing distances between the host vehicle and other vehicles traveling beside the host vehicle.

[0005] To deal with such a difficulty in giving the driver distance information, a technique disclosed in, for example, JP-B No. 2611173 uses a monitoring system including a plurality of cameras respectively provided with fish-eye lenses. The monitoring system calculates three-dimensional coordinates indicating the three-dimensional position of a moving object on the basis of a plurality of wide-angle images provided by the plurality of cameras to acquire distance information about the distance between the host vehicle and a vehicle traveling beside the host vehicle. However, it is not economically preferable to use such a monitoring system of complicated construction for obtaining information about a side space extending around the side of the host vehicle, which may be rough as compared with information about a forward space extending in front of the host vehicle.

SUMMARY OF THE INVENTION

[0006] The present invention has been made in view of such circumstances, and it is therefore an object of the present invention to provide a vehicle surroundings monitoring apparatus of simple construction capable of obtaining proper information about the surroundings of a host vehicle.

[0007] According to one aspect of the present invention, a vehicle surroundings monitoring apparatus for monitoring the surroundings of a host vehicle includes: image obtaining means each having an imaging lens system including a fish-eye lens; an image processing means capable of detecting a moving object on the basis of an optical flow between two images obtained by the image obtaining means respectively at different times, by using one of the images as a reference image, and of setting a representative point representing the moving object on the surface of a road; and a calculating means for calculating the position of the moving object relative to the vehicle on the basis of a displacement angle of the representative point from the optical axis on an image.

[0008] In the vehicle surroundings monitoring apparatus according to the present invention, the image obtaining means are disposed on right and left side parts of a body included in the host vehicle.

[0009] In the vehicle surroundings monitoring apparatus according to the present invention, the imaging lens system has an optical axis inclined slightly rearward to a direction parallel to the width of the vehicle.

[0010] In the vehicle surroundings monitoring apparatus according to the present invention may further include a display means for displaying the positions of moving objects relative to the host vehicle, capable of indicating the velocities of the moving objects relative to the host vehicle by vector notation.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] By way of example only, specific embodiments of the present invention will now be described, with reference to the accompanying drawings, in which:

Fig. 1 is a functional block diagram of a vehicle surroundings monitoring apparatus in a preferred embodiment according to the present invention;

Fig. 2 is a diagrammatic view for explaining image

regions obtained by a image obtaining means in an example;

Fig. 3 is a simplified diagram showing a distribution of velocity vectors;

Fig. 4 is a diagram showing a coordinate system for indicating angle of displacement from an optical axis;

Fig. 5 is a diagrammatic view for explaining the positional relation between a vehicle and a representative point;

Fig. 6 is a diagrammatic view of for explaining a method of calculating the distance between a vehicle and a representative point with respect to a direction parallel to an optical axis;

Fig. 7 is a diagrammatic view showing an image displayed on the screen of a display; and

Fig. 8 is a diagrammatic view for explaining image regions obtained by a image obtaining means in another example.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0012] Referring to Fig. 1, a vehicle provided with a vehicle surroundings monitoring apparatus 2 in a preferred embodiment according to the present invention, i.e. a host vehicle, has a body 1. The vehicle surroundings monitoring apparatus 2 obtains images of outside sceneries in set ranges, recognizes outside moving objects, such as vehicles traveling alongside the host vehicle and oncoming vehicles, and monitors the outside moving objects. The vehicle surroundings monitoring apparatus 2 comprises cameras (image obtaining means) 5 and 6 disposed on the right and the left side of the body 1 respectively, image processing units (image processing means) 7 and 8 capable of processing images obtained by the cameras 5 and 6 to detect moving objects, such as vehicles traveling alongside the host vehicle and oncoming vehicles, and setting representative points representing the detected moving objects on the surface of a road, a calculating unit (calculating means) 9 capable of calculating the respective positions of the moving objects relative to the host vehicle on the basis of angles of displacement of the representative points on the image to an optical axis, and a display (display means) 10 for displaying an image representing the calculated positional relation between the host vehicle and the moving objects.

[0013] The cameras 5 and 6 comprise imaging lens systems 5a and 6a including fish-eye lenses, and solid-state image sensors, not shown, respectively. The imaging lens systems 5a and 6a focus incident light on the surfaces of the solid-state image sensors, respectively. The cameras 5 and 6 have a large angular range of 180 degrees. As shown in Figs . 1 and 2, the cameras 5 and 6 are attached, for example, to rear parts of the body 1 at a height H, respectively, such that the optical axes O of the imaging lens systems 5a and 6a are inclined slightly rearward to a direction parallel to the width of the body 1 in a horizontal plane. As shown in Fig. 2, the respective angular ranges of the cameras 5 and 6 cover substantially entirely a space around the right and the left side of the body 1 and behind the body 1. In this embodiment, the vehicle is supposed to be a wagon and the body 1 is of a wagon type. Desirably, the cameras are attached to the D-pillars of the body 1.

[0014] The cameras 5 and 6 are connected to the image processing units 7 and 8 to give images to the image processing units 7 and 8, respectively. Also connected to the image processing units 7 and 8 are speed sensor 11 for measuring the traveling speed of the host vehicle and a steering angle sensor 12 for measuring steering angles. Each of the image processing units 7 and 8 produces an optical flow from the two successive images obtained at different times by each of the cameras 5 and 6 to detect moving objects, such as vehicles traveling alongside the host vehicle, and oncoming vehicles. That is, each of the image processing units 7 and 8 produces an optical flow indicating a distribution of velocity vectors in each of predetermined pixel blocks through the matching of the luminance pattern of the pixel block in the image taken at the later time, i.e., a reference image, and that of the pixel block in the image taken at the earlier time, i.e., a comparative image.

[0015] As shown in Fig. 3, velocity vectors representing the velocities of fixed objects, such as the surface of a road, have a direction substantially opposite to the traveling direction of the host vehicle and a magnitude substantially equal to the traveling velocity of the host vehicle. In contrast, velocity vectors representing the velocities of moving objects, such as vehicles traveling alongside the host vehicle, and oncoming vehicles, have magnitudes different from that of a velocity vector representing the traveling speed of the host vehicle. The image processing units 7 and 8 recognize a group of similar velocity vectors having magnitudes different from that of the velocity vector of the host vehicle as a velocity vector group representing the velocity of a single moving object for moving object detection.

[0016] The image processing units 7 and 8 set a representative point on a road surface on the basis of the detected velocity of the moving object for the moving object. That is, the image processing units 7 and 8 set a position, where the velocity vector of the lowest point of the moving object is in contact with the velocity vector of the fixed objects, as a contact point on the road surface. As shown in Fig. 3, when the moving object is a vehicle traveling alongside the host vehicle, the contact point where the moving object is in contact with the surface of the ground corresponds substantially to a point where a tire of the vehicle is in contact with the surface of the ground. The image processing units 7 and 8 draw a line segment L1 passing the contact point and parallel to the velocity vector group of the moving object on the image, draw a line segment L2 extending between a velocity vector at the head or the tail of the velocity vector

group and nearest to the host vehicle, and the center of field (optical axis O), and set a representative point A at the intersection of the line segments L1 and L2. As shown in Fig. 3, the representative point A does not necessarily coincide with an end of the body (moving object). In such a case, the representative point A has an error on the side of the host vehicle (safety side).

[0017] The image processing units 7 and 8 are connected to the calculating unit 9 to give information about the representative point A of each of moving objects on the image. The calculating unit 9 calculates the vertical displacement angle α and horizontal displacement angle β of the representative point A with respect to the optical axis O on the image. A coordinate system for indicating displacement angles with respect to the optical axis O on the image is set in the calculating unit 9, and the calculating unit 9 calculates the vertical displacement angle α and horizontal displacement angle β of the representative point A on the basis of the coordinate system. Then, the calculating unit 9 calculates a distance D1 to the representative point A along the optical axis O, and a distance D2 from the representative point A to the optical axis O along a perpendicular from the representative point A to the optical axis O.

[0018] Since the optical axis O extends in a horizontal plane at a height H from the surface of the road as shown in Fig. 6, the distance D1 is expressed by Expression (1) on an assumption that the surface of the road on which the representative point A is located and a contact surface with which the host vehicle is in contact are included in the same plane.

$$D1 = H \cdot \tan(90 - \alpha) \quad (1)$$

[0019] D2 is expressed by Expression (2).

$$D2 = D1 \cdot \tan\beta \quad (2)$$

Thus, the position of the moving object relative to that of the host vehicle is defined.

[0020] If a part of the body 1 is included in the field of view of the imaging lens systems 5a and 6a as shown in Fig. 6, the displacement angle $\alpha 2$ of a boundary between the body 1 and the surface of the road may be measured and may be used as reference information about the displacement angle α. The displacement angle $\alpha 2$ is dependent on the positions of the cameras 5 and 6, and the morphology of the body 1. If the positions of the cameras 5 and 6 include an error, the displacement angle $\alpha 2$ changes. Therefore, the accuracy of detection of the position of the moving object relative to that of the host vehicle can be improved by correcting the displacement angle α according to an error in the displacement angle $\alpha 2$.

[0021] The calculating unit 9 generates an output signal to be given to the display 10 on the basis of information about the respective positions of the moving objects relative to the position of the host vehicle. For example, a triangle representing the host vehicle is displayed in a central part of the screen of the display 10, and rectangles representing the moving objects, such as vehicles traveling alongside the host vehicle and oncoming vehicles, are displayed on the screen of the display 10. The velocities of the moving objects relative to the host vehicle are displayed by vector notation on the screen of the display 10. When the distance between the host vehicle and the moving object decreases below a predetermined threshold, a warning may be given to that effect by, for example, flickering the rectangle representing the moving object.

[0022] Since the vehicle surroundings monitoring apparatus 2 in this embodiment obtains images of objects around the host vehicle by the cameras 5 and 6 having the imaging lens systems 5a and 6a provided with fisheye lenses, respectively, the vehicle surroundings monitoring apparatus 2 is capable of Obtaining images of a wide range by using a small number of image obtaining devices.

[0023] The vehicle surroundings monitoring apparatus 2 is readily able to detect moving objects, such as vehicles traveling alongside the host vehicle, and oncoming vehicles, by producing an optical flow between two images successively obtained at different times, respectively.

[0024] The position of a moving object relative to the host vehicle can be readily calculated on the basis of the displacement angle from the optical axis O by setting the representative point A representing the detected moving object on the surface of the road. That is, the cameras 5 and 6 are set on the host vehicle with their optical axes O extended in a horizontal plane, and the distance between the host vehicle and the representative point A can be readily calculated on the basis of the displacement angle from the optical axis O on an assumption that the representative point A is in a plane including the surface with which the host vehicle is in contact. Therefore, any stereoscopic image processing operation and the like are unnecessary, the positional relation between the host vehicle and the moving object can be recognized from an image obtained by the single camera 5 or 6. Thus, proper information about the ambience of the host vehicle can be obtained by the vehicle surroundings monitoring apparatus of a simple configuration. The surroundings of the host vehicle can be effectively monitored by a small number of imaging devices by disposing the cameras 5 and 6 on the right and the left side of the body 1, respectively.

[0025] Images of regions which are difficult for the driver to monitor can be effectively obtained by disposing the cameras 5 and 6 with their optical axes O inclined slightly rearward to a direction parallel to the width of the host vehicle.

[0026] Indication of the velocities of the moving objects relative to the host vehicle by vector notation on

the display 10 is effective in making the driver recognize vehicles traveling alongside the host vehicle, and oncoming vehicles.

[0027] Although the vehicle surroundings monitoring apparatus 2 in the foregoing embodiment is provided with the cameras 5 and 6 disposed at the right and the left part of the body 1, the vehicle surroundings monitoring apparatus may be provided with cameras 15 and 16 disposed at right and left parts of the body 1, respectively, and a camera 17 disposed at a rear part of the body 1 as shown in Fig. 8. When the vehicle surroundings monitoring apparatus is provided with the cameras 15, 16 and 17, it is desirable to dispose the cameras 15 and 16 on the body 1 with their optical axes O extended in a middle part of the body 1 in parallel to the width of the body 1.

[0028] As apparent from the foregoing description, according to the present invention, the vehicle surroundings monitoring apparatus is simple in construction and is capable of acquiring information about the surroundings of the vehicle by using a small number of image obtaining means.

[0029] Although the invention has been described in its preferred embodiment with a certain degree of particularity, obviously many changes and variations are possible therein. It is therefore to be understood that the present invention may be practiced otherwise than as specifically described herein without departing from the scope thereof.

Claims

1. A vehicle surroundings monitoring apparatus comprising:

   image obtaining means each having an imaging lens system including a fish-eye lens;
   an image processing means capable of detecting a moving object on the basis of an optical flow between two images obtained by the image obtaining means respectively at different times, using one of the images as a reference image, and of setting a representative point representing the moving object on a surface of a road; and
   a calculating means for calculating the position of the moving object relative to the vehicle on the basis of a displacement angle of the representative point from the optical axis on an image.

2. The vehicle surroundings monitoring apparatus according to claim 1, wherein the image obtaining means are disposed on right and left side parts of a body included in a host vehicle, respectively.

3. The vehicle surroundings monitoring apparatus according to claim 2, wherein each imaging lens system has an optical axis inclined slightly rearward to a direction parallel to the width of the host vehicle.

4. The vehicle surroundings monitoring apparatus according to any one of claims 1 to 3 further comprising a display means for displaying positions of moving objects relative to that of the host vehicle, capable of indicating velocities of the moving objects relative to the host vehicle by vector notation.

5. A vehicle comprising the vehicle surroundings monitoring apparatus as claimed in any of claims 1 to 4.

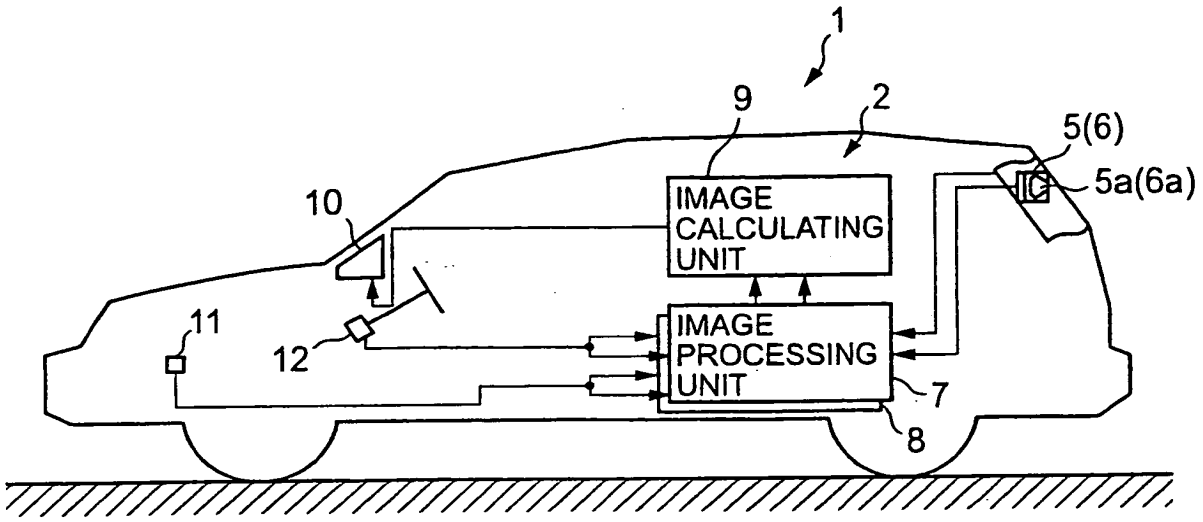
1
9
2
5(6)
5a(6a)
10
IMAGE
CALCULATING
UNIT
11
12
IMAGE
PROCESSING
UNIT
7
8

FIG.1

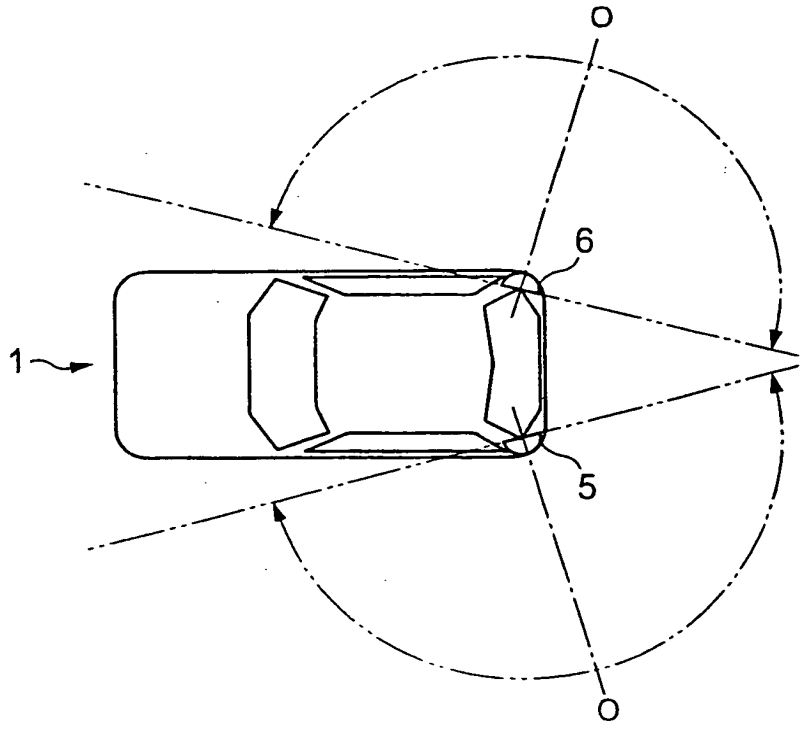
O
6
1
5
O

FIG.2

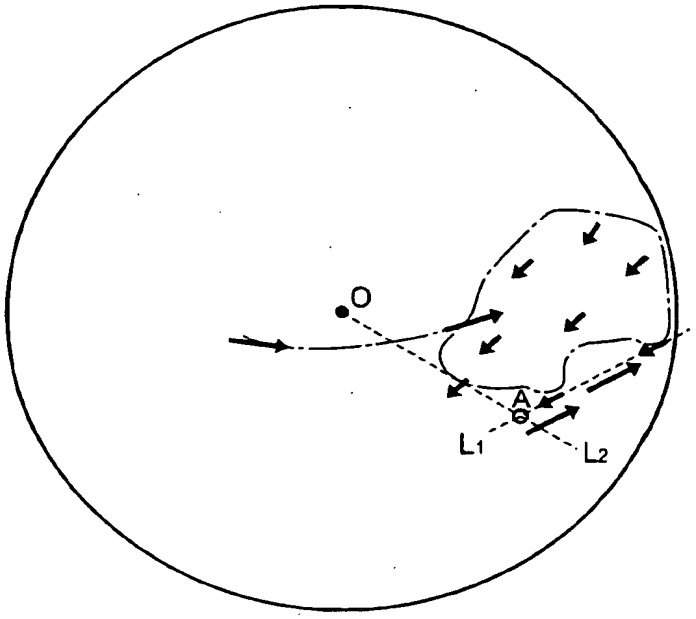

FIG.3

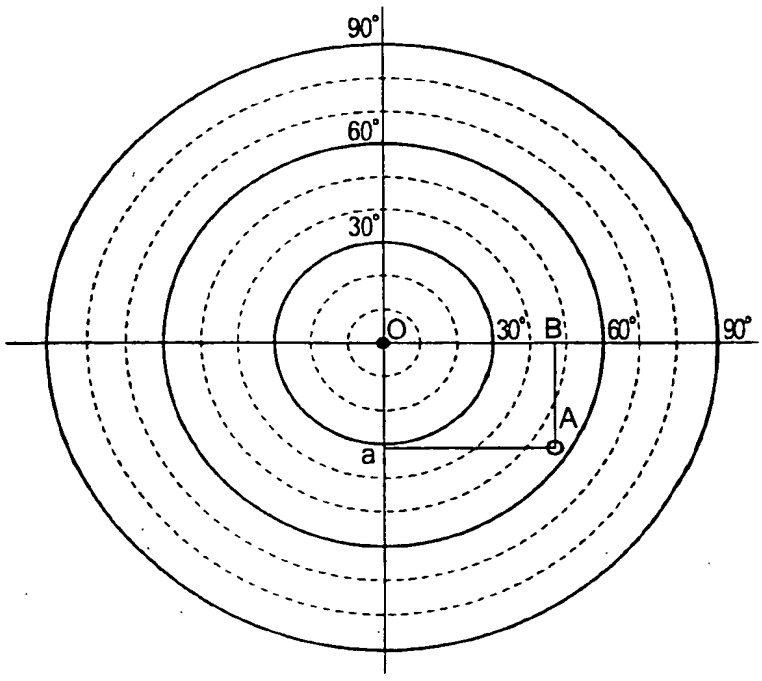

FIG.4

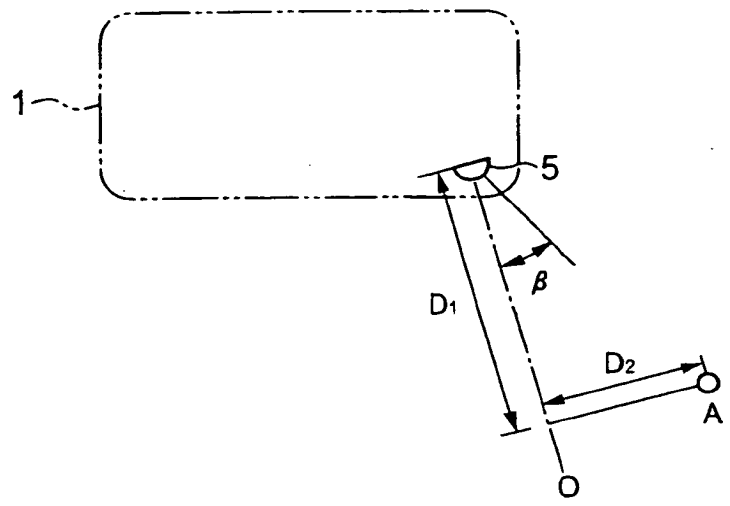

FIG.5

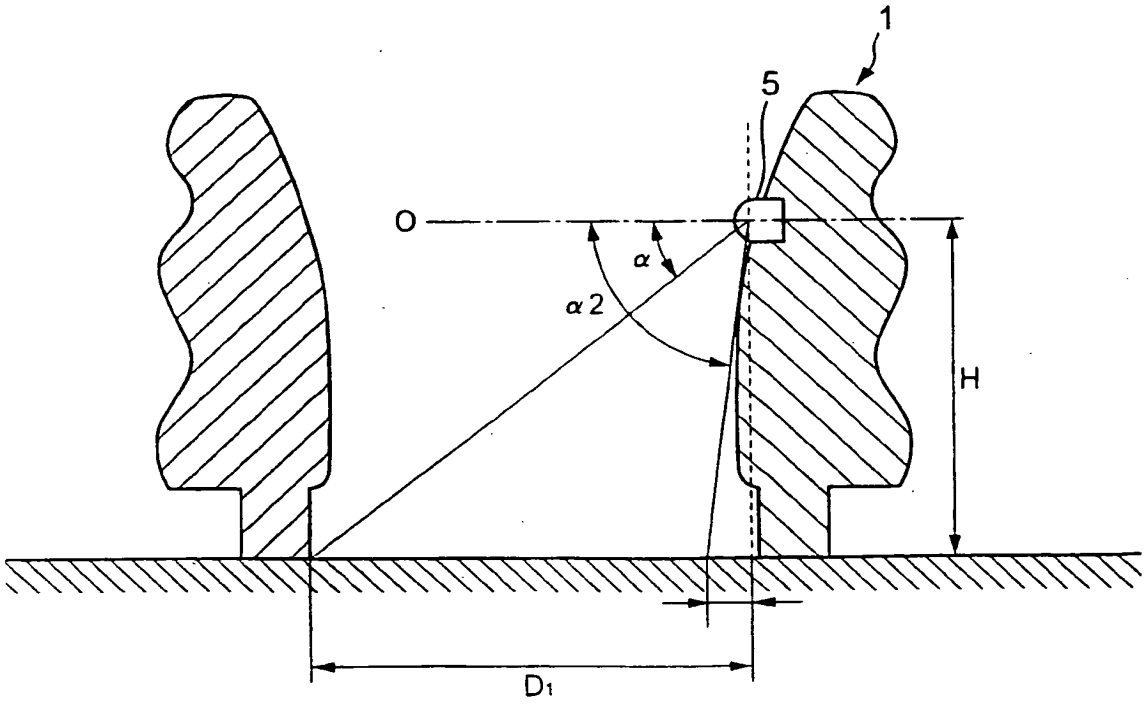

FIG.6

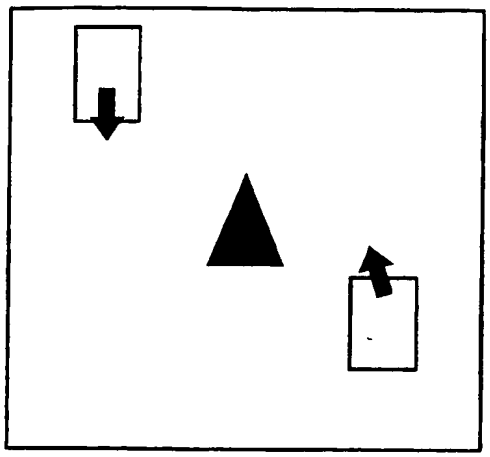

FIG.7

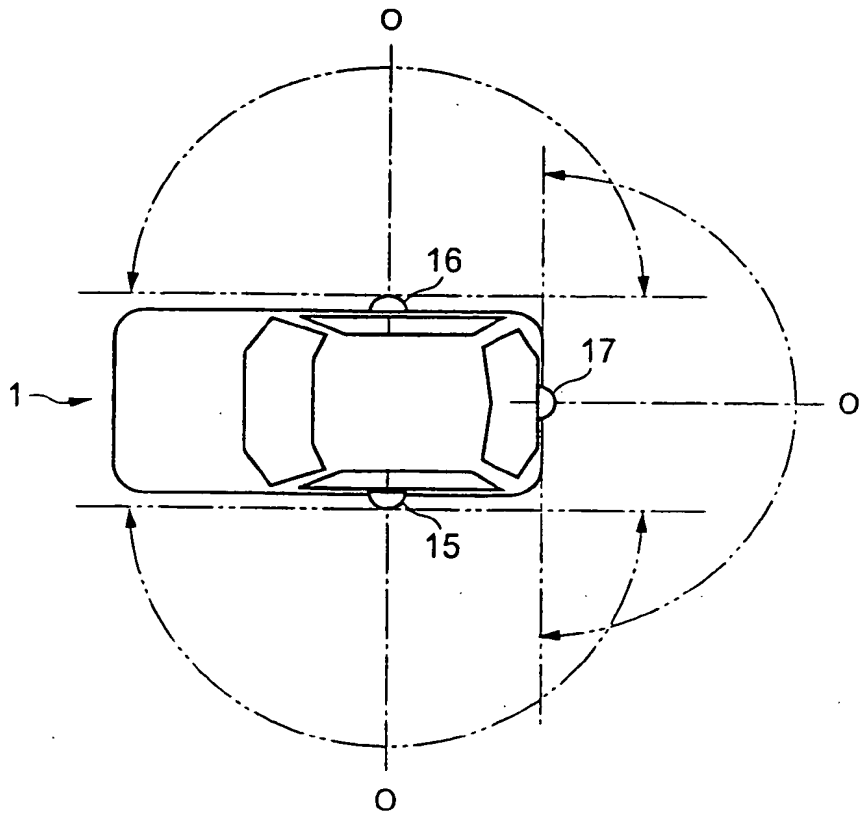

FIG.8

THIS PAGE BLANK (USPTO)